A quaternary ammonium bromide-containing polymer for polyurethane surface modification

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Introduction

Polyurethane has been used in biomedical areas as cardiovascular medical devices due to its excellent biocompatibility and mechanical properties. However, their inherent hydrophobic surface and bacterial-associated infection limit their applications [1]. Hydrophobic surface can lead to nonspecific protein adsorption, cell adhesion and bacterial adhesion. Bacterial adhesion or biofilm formation can cause biomaterial-associated infections. Regarding polyurethane surface modification studies for decreased protein adsorption and cell adhesion, some are related to synthesis of entire hydrophilic polyurethanes before forming a medical device but some are focused on modification of the surfaces of the formed medical devices. To prevent bacterial infections, three strategies have been used: (1) To create a non-fouling surface, which resists or reduces protein, cell and bacterial attachment; (2) To incorporate antibacterial agents such as silver ions, zinc ions, iodine, antibiotics and chlorhexidine into the materials. Bacteria or fungi are inhibited or killed by slow or extended release of the above antibacterial agents. However, release or slow-release creates several problems including short-term effectiveness, possible toxicity to surrounding tissues, and enhancing the chance for antibiotic-resistant bacteria formation due to the gradually decreased level of the released agents; (3) To covalently attach antibacterial agents onto polymer surfaces and inhibit or kill bacteria by surface contact. This strategy is designed for long-term disinfection and reduces the risk of antibiotic-resistant bacteria formation. Quaternary ammonium salts are the most studied antibacterial compounds so far for bacterial inhibition based on the principle of inhibition or killing of bacteria by contact [2]. Their popularity is attributed to the reason that they can be easily derivatized and grafted onto a polymer chain as a residue or incorporated as a comonomer into the polymer chain.

The objective of this study was to synthesize a quaternary ammonium bromide (QAB)-containing antibacterial polymer, attach the polymer onto the polyurethane surface, and evaluate the modified surface with contact angle, bacterial viability and protein adsorption tests.

Materials and Methods

The polymer containing QAB, N-vinylpyrrolidone and succinimidyl acrylate at a molar ratio of 85/10/5 was synthesized based on the published protocol [3]. Then the purified polymer was attached onto the activated polyurethane surface [3]. FT-IR was used to characterize the functional groups on the modified surface. Surface contact angle, bacterial viability and protein adsorption were also used to evaluate hydrophilicity, antibacterial activity and surface protein adsorption of the modified surface [3]. Three bacteria species including *S. aureus, P. aeruginosa and S. epidermidis* were used to assess the antibacterial activity. Human serum albumin was used to assess the surface protein adsorption.

Results

With hydrophilic NVP incorporation, the modified surface showed significantly increased hydrophilicity by exhibiting 18 to 47% decrease in contact angle (Fig. 1). With QAB addition, the modified surface showed enhanced antibacterial properties by exhibiting 15 to 46% reduction in bacterial viability (Fig. 2). The modified surface also showed a reduced protein adsorption by demonstrating 2 to 35% decrease in human serum albumin adsorption. Furthermore, Increasing substitute chain length on QAB increased contact angle, protein adsorption and antibacterial activity.

Conclusion

It appears that surface modification with QAB/NVP copolymer can significantly increase hydrophilicity and antibacterial activity and reduce protein adsorption.

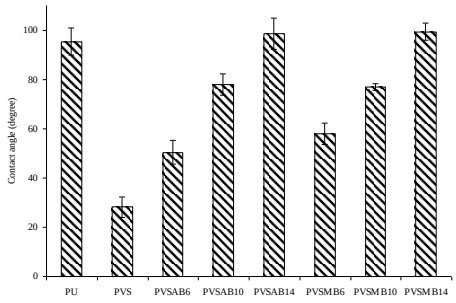

Fig. 1. Effect of poly(VP-co-SA-co-QAB) on surface contact angle.

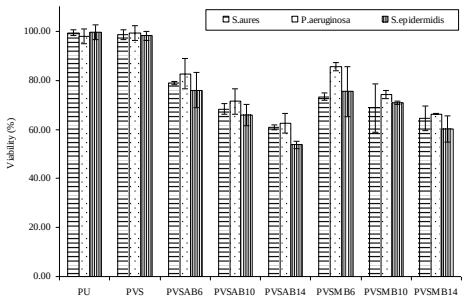

Fig. 2. Effect of poly(VP-co-SA-co-QAB) on viability of *S. aureus, P. aeruginosa and S. epidermidis*.

References

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